Draft Version 4.1

NASA
Jet Propulsion Laboratory
California Institute of Technology
Pluto Fast Flyby Preproject
Jackie Giuliano, Coordinator
Educational Outreach
4800 Oak Grove Drive 301-250D
Pasadena, CA 91109

Pluto Fast Flyby Preproject Curriculum Guide

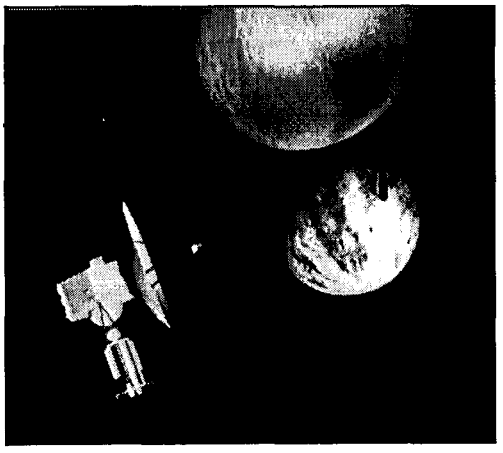
Volume 1 No. 1
October 1994

PLUTO: A New Way To Explore the Planets

By Richard Shope and Jackie **Giuliano**

The Pluto Fast Flyby Mission is an exciting adventure *beginning the next century with a new way to explore the planets,* The Pluto Preproject Team at the Jet Propulsion Laboratory is leading the effort to design and build two spacecraft equipped with components at the cutting edge of advanced technology. 'I'he proposed odyssey inthe first years of the ncw century will be achieved through the combined efforts of American and Russian project teams, and perhaps using Russian launch vehicles known as Protons. After seven to nine years in flight, these two innovative, cost-effective spacecraft will provide us the first ever view of the last unexplored planetary system: the mysterious planet Pluto and its enigmatic moon, Charon.

The video "*Out of the Darkness: Mission To Pluto*" (JPL AVC-94-164) provides an overview of this mission and an opportunity to involve your students in the challenges of such an ambitious endeavor.



The cost-e fficient Pluto Fast Flyby spacecraft ***encountering Pluto and its moon Charon.***

Involve your students in the thrill of discovery!

The Pluto Fast Flyby video affords an opportunity for the teacher and student to explore many concepts. These curriculum guides have been designed to provide the teacher at any grade level with ideas and suggestions for activities that involve students physically as well as imaginatively.

Educational Objectives

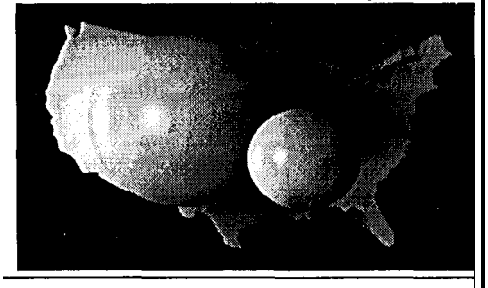
Af-A-Glance

1. To THINK CRITICALLY about why we should explore the planet Pluto!
2. To THINK CREATIVELY about small spacecraft DESIGN!
3. To 1DENTIF% planetary bodies in the Solar System !
4. To STATE the relative distances of the planets in terms of astronomical units!
5. To DEFINE: *planet, asteroid, comet, sun, solar system, astronomical unit, orbit, satellite, stereopsis, blink comparator and other important term!*
6. To DESCRIBE the processes involved in space exploration!
7. To GET INVOLVED!

Key Questions For Discussion

- How do we know how far Earth is from the Sun?
- How can we compare the relative planetary distances?
- Why are the planets named for Roman gods?
- Is Pluto always the farthest planet?
- What are the shapes of the planetary orbits?

Art by Jeff Alu



inside...

Exercise 1: Interplanetary Distances

Key Concept: Planet Means *Wanderer*

Planets and planetary bodies--asteroids and comets-- appear to *wander* in relation to the relatively fixed stars. This appearance results from our Earth-bound view of planets as they orbit the Sun, As these objects in the Solar System are so much closer to Earth than the stars, their motions are more readily apparent, In effect we are engaged in a marvellous dance of the planets around the Sun. Our first dance step is to experience the vast scale of the solar system.

With the information from the Astronomical Unit table below, have students work in teams of 11-15 in a group. Each team must choose an arbitrary distance to represent an Astronomical Unit (for instance, a team member with arms outstretched). Each team has the task to create a scale mode] of the relative distances of the solar system on the playground or nearby park area, or even in the hallway. Each team member acts as one of the objects in the solar system. The activity generally takes about twenty five minutes for each team to accomplish the task.

COMMENTARY

The Astronomical Unit is useful within our solar system to help us comprehend the distances involved. But without some intuitive sense for what an AU is, it remains an abstract term. The activity is designed to give a kinesthetic feel for the kind of distances involved. After such an participatory exercise, everyone has a common frame of reference for discussions that follow.

VARIATIONS

1 With chalk, mark the positions of each planetary body.
2 Work out the orbital path of each planetary body, and mark it out with chalk, string, or rope.
3 Set the Solar System in motion with these calculations.
4 Consider distances beyond the Solar System. If Pluto is across the playground from the Sun, how far away is Alpha Centauri, the next nearest star?

RESEARCH QUIUSTIONS

1 Since its discovery in 1930, Pluto has only moved about one quarter of its orbit around the Sun. How do we observe, predict, and refine our understanding of its orbital path?
2 What other units of measurement can we use to function within the solar system?

GOING INTO **DEPTH**

1 The relative distances of the visible planets were observed and recorded by ancient skywatchers. What naked eyc observations are necessary to determine the distance of the visible planets?
2 The absolute distance between Sun and Earth was not fully calculated until recent times. What observations and basic principles allowed astronomers to calculate this value?

Pluto Fast Flyby Preproject Educational Outreach

Preproject Manager
Rob Staehle

Educational Outreach Coordinator
Jackie Alan Giuliano

Curriculum Development Lead
Richard Shope

NASA
Jet Propulsion Laboratory
California institute of Technology
Mail Stop 301 -250D
4800 Oak Grove Drive
Pasadena, CA 91109

(818) 354-3812

pluto.education@jpl.nasa.gov

ASTRONOMICAL UNIT

'or interplanetary distances we use the *Astronomical Unit*, a handy ruler that corresponds to the verage distance between the Sun and Earth: about 93 million miles or 150 million kilometers.

A.U.

Feel free to experiment with yout own variations of these exercises!

Send any suggestions and ideas you'd like to share to the Pluto Educational Outreach Office at the Jet Propulsion Laboratory!

–We'd love to hear from you!

Interplanetary distance can be expressed in Astronomical Units or A. U., as follows:
(Figures represent A VERAGE distance)

OBJECT	DISTANCE FROM SUN
Sun	O A.U.
Mercury	0.4 A.U.
Venus	0.7 A.U.
Earth	1.0 A.U.
Mars	1.5 A.U.
Asteroid Belt	2.8-3,0 A.U.
Jupiter	5.2 A.U.
Saturn	9.5 A.U.
Chiron	13.7 A.U.
Uranus	19.2 A.U.
Neptune	30 A.U.
Pluto	39 A.U.

Exercise 2: Name That Planet

Naming celestial bodies after figures from Greek and Roman mythology follows a tradition set when the language of science was Greek and later, Lat in. Medieval and Renaissance Europe reflected back toward Greece and Rome as the civilizations that gave Europe its impetus toward knowledge. While ancient African, American, Arab, and Asian cultures also developed equally rich traditions of astronomical observation and understanding, we still follow the custom of naming newly discovered major and minor planets for Greek and Roman mythical figures.

Mercury was so named because it moves rapidly about the Sun, just as the fleet-footed messenger of the gods skims the surface of the sea with his winged sandals. Venus, who shines so brilliantly in the morning and night skies, presiding over the twilight hours, inspired an association with the goddess of love and creativity herself. The red glow of Mars suggested the fire of battle, and so the planet was named for the god of war, Jupiter moves steadily across the sky, as the god Jupiter rules with a steady hand. Saturn, the great titan, son of Sky and Earth, ruler of time, father of the Olympian loomed ancient in the outermost skies.

Throughout the world, known by many different names, these planets, visible to the naked eye, enacted a heavenly drama, as symbols or as manifestations of divine beings themselves, maintaining the order of the cosmos for all humankind.

As telescopes extended the vision of observers, new major planets were discovered: Uranus in 1781, named for the figure whose union with the Earth goddess, Gaia, produced order out of chaos; and Neptune in 1846, named for the god of the Sea, brother of Jupiter.

Pluto was discovered by Clyde Tombaugh, aged 24, a student astronomer, working at the Lowell Observatory on February 18, 1930. The popular press focused as much attention on the naming of the new planet as on the science involved. There were those who argued that, as people of modern times, we should break with tradition. Some urged naming it in honor of Percival Lowell, whose calculations had stimulated the search for an undiscovered Planet X. 'l'he public offered many suggestions, Most popular were Minerva, the goddess of wisdom and war, and Pluto, god of the land of the dead and brother of Jupiter and Neptune, To those at the Lowell Observatory, Pluto won out, as seeming appropriate for the coldest and most distant planet. The name also allowed a way of honoring Percival Lowell, by fashioning a monogram of his initials, P. L., —which also happened to be the first two letters of *Pluto*— to be the new planetary symbol .

In the end the naming was credited to a young girl, aged 11, Miss Venetia Burney of Oxford, England, who had cabled Lowell Observatory with her suggestion shortly after initial news of the discovery had reached the world.

Student Involvement with Pluto exploration has **been a tradition from the start!**

Activity
Name *Your* Planet!

Omagine that YOU have just discovered a new planet in the Solar System! What would you name it and WHY? Don't feel limited ONLY to names from Greek and Roman mythology! Use your WHOLE IMAGINATION!

individually or in teams DRAW your own picture of the new PI.ANET.

NAME THAT PI. ANET! Think about the meaning of name ideas and why they might fit.

CREATE A STORY that goes with your planet's name.

READ & MIME the story as you would wish to present it to others in the class.

Today, all names of newly discovered planetary bodies are approved officially by the International Astronomical Union.

Postal Address: Central Bureau for Astronomical Telegrams , Smithsonian Astrophysical Observatory, Cambridge, MA 02138, U.S.A.

What's In A Name?

By tradition, the discoverers have the right to suggest the name for a new planet. Lowell Observatory received letters, and cables, with suggestions from A to Z.

Amphitrite, Apollo, Artemis, Athenia, Atlas, Bacchus, Constance (Lowell's wife), Cronus, Diana, Erebus, Idana, Loki, Lowell, Minerva, Osiris, Pax, Percival, Perseus, Salacia, Tantalus, Vulcan, Zeus, & Zymal (the last word in the dictionary..

Whose dictionary? Who has the last word in YOUR dictionary?

Exercise 3: Science & Mythical Archetypes

Mythical archetypes are powerful symbolic structures, laden with deep meaning, that carry the basic values of a culture from generation to generation. Archetypes recur in mythical stories that are related from parent to child, teacher to student, and artist to audience. In centuries past, the tradition of folktale and mythology transmitted this wisdom of the people and projected their stories onto star constellations and planets. Pluto and Charon are named for Greek & Roman mythical figures. Here you will find some of the stories attached to their names. Many scholars suggest that myths also represent a tradition of oral history. The story of Pluto and Persephone maybe symbolic of the struggle of a patriarchal culture taking power from a more ancient matriarchal culture. Today, the more ancient stories are also being rediscovered.

ACTIVITY

READ and MIME these myths!

CREATE your own stories based on mythical archetypes!

Pluto & Persephone: Story of the Seasons

Pluto emerged from the Underworld to kidnap Persephone and take her to be his Queen. Demeter, her mother, angrily searched the world for her daughter, refusing to allow fields to grow, until Persephone was returned. Winter lingered in the world. Finally, Demeter discovered the truth. She demanded that Jupiter force Pluto to return Persephone. Jupiter granted this request on the condition that Persephone had not eaten any food there. Alas, she had eaten seeds of a pomegranate. So for part of the year she may come above, in the time of spring, summer and fall-- and for the rest of the year she must live below, with Pluto in the Realm of the Underworld-- in the time of winter.

The Poets Homer, Hesiod, Ovid, Vergil, & Dante, all told these stories based on mythology!

Pluto, The Rich One

After the Olympian gods overthrew the Titans, Jupiter claimed realm of the Heavens, Neptune the realm of the Sea, and Pluto became Lord of the Underworld. the realm of the Dead, and of the wealth drawn out of the depths of the Earth. People considered it bad luck to utter his true name, Hades, preferring the name Pluto, meaning "The Rich One."

The 12th Labor of Hercules

The hero Hercules scowle at Charon to cross the River Styx to accomplish his Twelfth labor, subduing the three-headed beast Cerberus who guards the gate of the entrance to the Underworld.

Dante Meets Charon

"The Poet Dante structured his Divine Comedy according to the cosmology of his day,a geocentric vision of infernal and heavenly circles. Dante crosses the River Styx over the objections of Charon, whose charge is to carry the souls of the dead, not of the living. Only by the admonition of Vergil under the authority of Beatrice, representing Divine love, does Charon let Dante pass.

ORPHEUS

Orpheus was the greatest singer of ancient times. His voice soothed even the trees and mountains, calmed the storms of the sea and assuaged the ravages of war. Orpheus loved Eurydice. As she was gathering flowers by the stream, reaching for a lily, a venomous snake bit her, and she died. Her spirit descended to the shores of the River Styx, whre Charon escorted her to the realm of Pluto, land of the dead. Orpheus was so griefstruck, he followed Eurydice's. Charon, the boatman, refused to let Orpheus pass, for no living souls were permitted to enter Pluto's realm. Orpheus strummed his lyre and sang a plaintive song that so soothed Charon, tears streamed down his cheek. He motioned to Orpheus to board his ferry to cross the River Styx. When he reached the throne of Pluto and Persephone, Orpheus sang with all his heart to win Eurydice back to life. So charmed, the gods granted his request, on the condition that he not look back until she fully emerged from the depths to enter the light of the living. All went fine until, so tempted, he looked back a moment too soon, losing Eurydice forever.

Exercise 4: The Search for the Ninth Planet

Planet X

The search for Planet X proceeded from two main assumptions:

- *Mathematically according to "node's Rule" there ought to be another planet out there to fit the scheme.*
- *The orbits of Uranus & Neptune seemed perturbed by some unseen source of gravitational force.*

EDUCATIONAL OBJECTIVES
AT-A-GLANCE

1. To IDENTIFY general features of planetary motion.

2. To STATE the history of the search for Pluto.

3. To DEFINE: *stereo scanning, stereopsis, blink comparator, photographic plate, planetary body.*

4. To DESCRIBE the process of searching for Pluto and other planetary bodies.

BACKGROUND DISCUSSION

THE SEARCH BEGINS

Stars are so distant from us that they appear to be fixed in their relative positions in the night sky. When we look at photographs taken through telescopes that are coordinated with the movement of Earth's rotation, the relatively nearer objects within the Solar System appear to change position over a short period of time. If they are moving very fast or are very close --like-a comet or an asteroid-- they may appear as streaks on the photographic plate. These planetary bodies will appear in different positions in successive photos.

Observers can detect planets, asteroids, and comets by closely examining photographs of the night sky. The film is capable of recording images of objects FAINTER than we can see with our own eyes. Once the photos are developed, we CAN see the images of the stars and planetary bodies, By looking closely among the hundreds of tiny luminous specks, we can discover new planetary bodies.

Bode's Rule is a mathematical pattern that was noticed by German astronomer Johann Titius and popularized by his colleague Johann Bode in 1772, still useful today as a handy way to remember the distances of planets from the Sun.

Bode's Rule has no theoretical basis and is more descriptive than explanatory. The regular spacings, however, imply an evolutionary rather than a catastrophic process of planet formation. Exactly why the planets happen to fit the scheme remains unknown-- but the existence of the scheme formed part of the drive to LOOK beyond Neptune to find a ninth major planet. Following the discoveries of Uranus (1781) and Neptune (1846), astronomers detected variances from their expected positions that suggested yet another planet.

Thus on two fronts, the continued search for a Planet "X" was justified. As it turns out, both assumptions driving the search were erroneous. Eventually, with more advanced technological tools astronomers realized that the apparent perturbations were due to *miscalculations* of the masses of Uranus and Neptune. Nevertheless, the assumptions led scientists to LOOK.

Though we may look for the wrong reason, we may yet make an important discovery.

Bode's Rule (see Table Below)

"Write down a row of 4s, one for each planet, and add the sequence, 0, 3, 6, 12, 24, and so on, doubling each time. Then, divide the sums by ten to get the number of astronomical units between each planet and the Sun."

Neptune is the only planet for which Bode's Rule does not fit.

A

Mathematical patterns often lead us to discover important underlying principles.

What patterns have you noticed that can be expressed mathematically?

	Mercury	Venus	Earth	Mars	Asteroids	Jupiter	Saturn	Uranus	Neptune	Pluto
	4	4	4	4	4	4	4	4	4	4
	0	3	6	12	24	48	96	192	--	384
Predicted	0.4 A.U.	0.7 A.U.	1.0 A.U.	1.6 A.U.	2,8 A.U.	5.2 A.U.	10.0 A.U.	19.6 A.U.	--	38.8 A.U.
Actual	0,4 A.U.	0.7 A.U.	1.0 A.U.	1,5 A.U.	2.8 A.U.	5.2 A.U.	9.5 A.U.	19.2 A.U.	30.0 A.U.	39.4 A.U.

Table 1. Bode's Rule (Source: Hartmann, 1992. *The Cosmic Voyage)*

COMMENTARY

Clyde Tombaugh's Blinking Persistence

Astronomers searching for new planets, line up photos of the sky taken on different nights together in such a way that the fixed stars are in virtually identical positions in each photo. Two main methods can be used to perceive a meaningful new discovery in the midst of those thousand of specks: the blink method and the stereo scanning technique.

In the winter of 1929-30, Clyde Tombaugh, aged 24, searched systematically through millions of images of stars on hundreds of photographic plates to find Pluto. By setting up pairs of photos side by side, of identical sections of night sky taken on different dates, he was able to compare the two fields of stars.

When looking through a device called a *blink comparator,* a light is blinked on and off alternating between the two photographic plates. Each plate is viewed momentarily, but the blinking proceeds so rapidly that the image appears as continuous, when in fact it is not --just as a motion picture is composed of many still photographic frames shown in rapid ssuccession..

An out of place speck will appear to jump up and down or side to side, while all the relatively fixed stars appear identically placed and therefore seem still. A flip book of a series of images demonstrates a similar effect. The jumping movement is a result of the planetary body travening along its orbit against the background of the more distant stars. The perception is one of *motion.* Our eyes arc designed to detect motion. If a movement occurs within our visual field we notice it instantly.

On February 18, 1930, the speck that would reveal the position of the new planet jumped off the plates and into view, Just as ancient skywatchers noticed the nearer and brighter planets through constant and persistent watching, so Tombaugh searched diligently with the aid of the technology available at the Lowell Observatory in Flagstaff, Arizona.

Today, astronomers discover many new planetary bodies such as asteroids and comets through similar methods. The painstakingly tedious process is nevertheless rewarding when a new planetesimal is Discovered, confirmed and then named for its discoverer, placed in the Astronomical Ephemeris for all to see,

Photo: Courteous of Clyde Tombaugh

Clyde Tombaugh in 1928 with his home-made 9-inch telescope,

Find out how
YOU CAN MAKE
YOUR OWN TELESCOPE!

In 14 years, Tombaugh photographed and scanned:
338 plate pairs (14x17-inch), 24 plate pairs (8x10-inch).
7000 hrs at the blink comparator= 3.5 work-years just scanning!
Not to mention time in the dome and darkroom!
30,000 sq.degrees (270 sq. ft. of plate surface)
Were blinked before finding Pluto
44,675,000 x 2 stars scanned in Planet-X search
= (6,382 stars/hour or about 2 stars/see for 3.S years) . . . x 2 ! ! !
Yikes! I can't see anymore!!!!

Discoveries made during
Planet-X search
(in order of importance):
1- Trans-Neptunian planet
1- Globular Star Cluster
1- Super-Cluster of galaxies
5- Open Galactic star clusters
1- Comet
775- Asteroids

ACTIVITY

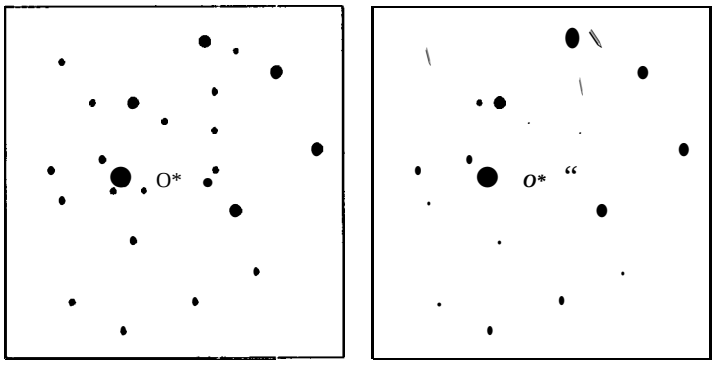
Search for the Planets: STEREO SCANNING

Asteroid and comet searching at the Jet Propulsion laboratory is an ongoing process. A more common discovery method than blinking nowadays is known as *stereo scanning*.

Our depth perception is a result of stereo seeing. Each of our eyes form images of the world from slightly different angles, depending on the distance between them. The two images are superimposed by the processes of the brain. instead of seeing double, the two fields merge into one. If you holdup a finger at arms' length in front of you, and alternately close one eye and then the other, you will notice that the background beyond your finger shifts. Each eye defines a slightly different point of view. This illustrates the effect called *parallax.*

Under special circumstances, stereoptical illusions may be produced. For instance, at arms' length, touch your two index fingers together, as if each is pointing toward the other. Now, separate them slightly by a small space, keeping them lined up. Slowly,, bring both hands closer and closer to your eyes. Relax your eyes into a soft focus. Don't try too hard to keep your fingers in perfect focus. You will notice that suddenly you see not only your two fingers, but a third, Vienna sausage-sized image of your fingertips!

You have experienced a perfectly natural phenomenon known as *stereopsis*. Your vision has merely done what it is meant to do-- to superimpose the two visual fields of the left and right eyes. Only at such close range does this become process become an illusion. This effect is the basis of *stereo scanning.*



Above you will find a simplified representation of a photo of an area of night sky where a planet may be. The two pictures ook identical. But they are not. With the thousands of stars that would normally appear in such a photo, looking for that faint trace of difference could become extremely difficult. The task is vastly simplified by using stereo scanning. Try it yourself!

Hold the drawing in both hands. Place the drawing at arms' length. Relaxing to a soft focus, bring in your arms until the bird, superimposed image becomes visible in the center. The image will appear identical to the outer images except that any speck hat is different will seem to float off into a different visual plane. By noticing this and identifying its location on each photo, the astronomer has formed the initial steps of confirming the presence of a new planetary body.

By looking through hundreds of thousands of photographic plates, using various devices, such us blink comparators and stereo microscopes, astronomers all over the world have identified tens of thousands of interplanetary bodies.

KEY CONCEPT

How to Search for Planets, Asteroids, & Comets

Predictions of Pluto by Percival & Pickering

Orbital Elements	Planet X (Lowell)	Planet O (Pickering)	Pluto (1930)
a (mean distance)	***43.0***	***55.1***	**39.5**
e (eccentricity)	0.202	0.31	0.248
i (inclination)	10° ±	150 *	**17°.1**
Ω (ion.gitucle,node)	not predicted	***100°*** ±	109°.4
ϖ (longitude,perihelion)	2040.9	2800.1	2230.4
μ (mean annual motion)	***1°.2411***	0°.880	1°.451
P (period, in years)	***282***	409.1	**248**
T (perihelion date)	***1991.2***	2129.1	**1989.8**
L (longitude, 1930.0)	102°.7	102°.6	**108°.5**
m (mass, earth=1)	6.6	***2.0***	**< 0.7**
M (magnitude)	12-13	15	**15**

Table 2. Lowell and Pickering's Predictions Compared (Source: Hoyt, 1980. *Planets Xand Pluto)*

BACKGROUND DISCUSSION

THE SEARCH GOES ON

Two turn of the century astronomers, Percival Lowell and William Pickering, worked out predictions for the ninth mystery planet in detail. Each one was partly right and partly wrong. Lowell had a more accurate position, but a less accurate mass; Pickering had a better estimate of the mass, but was off on the posit ion.

Pickering had put the search on the back burner, while astronomers at the Lowell Observatory pursued the search in the years after Lowell's death-- thus Lowell's efforts are credited for providing the greater impetus toward the actual discovery of Pluto by Clyde Tombaugh in 1930.

VARIATIONS

Make a Flip Book

Create a pattern of planetary motion against an identical background fixed stars.

Star Clusters of Students

Designated "asteroids" or "comet" at far end of playground area. Observer 1.00 KS, then closes eyes. One "asteroid" or "comet" moves. ***Can*** the ***Observer tell who moved?***

Make Up Your Own Variations!!

RESEARCH QUESTIONS

(Going Into Depth)

- How do we explain the motion of planetary bodies against the background of "fixed stars" ?
- How dependent are we on the visual acuity of observers?
- How do we explain the apparent motion of stars?
- How are telescopes rigged to compensate for the motion of Earth?
- What are the faintest objects in the night sky that the naked eye can detect as compared to using a telescope?

SOURCES & BIBLIOGRAPHY

1. Abell, Morrison, Wolff, Realm of the Universe. Saunders College Publishing
2. Berry, Arthur, A Short 1 listory of Astronomy, 1961. Dover Publications.
3. Ferris, Timothy, Coming of Age in the Milky Way, 1989.
4. Graves, Robert, The Greek Myths, 1960. Penguin Books.
5. Greeley, R., Planetary Landscapes, 1987. Unwin/Hymen Publishers.
6. Grossinger, Richard, The Night Sky: The Science and Anthropology of the Stars and Planets, 1988. New York: St. Martin's Press.
7. Hartmann, William K. and Miller, Ron, Cycles of Fire: Stars and galaxies and the Wonder of Deep .Space, 1987. Workman Publications,
8. Hartmann, William K., "The Cosmic Voyage. 1992. Belmont, CA: Wadsworth Publishing Company.
9. Hoyt, William Graves, Planets X and Pluto, 1980. Tucson, AZ: University of Arizona Press.
10. Kaufmann, William J., Relativity and Cosmology, 1973. Harper and Row.
11. Littman, Mark, Planets Beyond: Discovering the Outer Solar System, 1988. Wiley Science Editions.
12. McAleer, Neil, Omni Space Almanac, 1987. Omni Publishing
13. Muskie, Edmund, The U.S. In Space: Issues and Policy Choices For A New Era, 1988. Center For National Policy Press, Washington, D.C.
14. Ridpath, Ian, Monthly Sky Guide, 1987. Cambridge University Press.
15. Sheean, William ., Planets & Perceptions: Telescopic Views and Interpretations, 1609-1909, 1988. Tucson, AZ: University of Arizona Press.
16. Sky and Telescope Magazine, Sky Publishing Corporation,
17. Smith, Arthur, Planetary Exploration, 1988. Sterling Publishers.
18. Stone, Merlin, Ancient Mirrors of Womanhood: A Treasury of Goddess & Heroine Lore~r~!~fir~ll~ld.the World, 1991. Boston: Beacon Press.,
19. The Geology of the Terrestrial Planets, 1984. NASA Publication S1'-469. Available from the U.S. Government Printing Office.
20. Tombaugh, Clyde W. & Patrick Moore, Out of the Darkness— The J'la.net Pluto, 1980. Lutterworth Press,